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CERMET SOLDER FOR HIGH-PRESSURE SODIUM-VAPOR LAMPS

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A new composition of cermet solder for high-pressure sodium-vapor lamps is proposed. This cermet solder will make it possible to attain lamp service life to 12,000 h with high specific electric load and considerably improve the quality and significantly expand the practical applications of the lamps manufactured.

Key words: cermet solder, alloy, composition, temperature.

The melting temperature of solder (metal or alloy used to join blanks) is significantly lower than the materials being joined (metal, glass, ceramic, and so on). Soldering is used to create a mechanically strong (sometimes hermetic) seam, obtain an electric contact with a low contact resistance, and so on. In soldering the location of the solder – blank joint is heated. Different physical-chemical processes occur at the boundary between the fused solder and solid metal (or other materials) [1].

Solder is picked on the basis of the physical-chemical properties of the metals (materials) being joined and the required mechanical strength and corrosion resistance of the joint. The conductivity of the solder must be taken into account when soldering current-conducting parts. Solders are customarily divided into two groups — soft and hard. Soft solders melt at temperatures up to 300 °C and hard ones above 300°C. In addition, solders differ considerably with respect to mechanical strength. The ultimate tensile strength is 16 – 100 MPa for soft solders and 100 – 500 MPa for hard solders [1].

Different types of sodium-vapor lamps are manufactured using cermet solder (CS) consisting of calcium, zirconium, aluminum, and magnesium oxides. This solder is used for soldering metal with ceramic; it operates at relatively low temperatures and has a short service life. However, it does not always satisfy the requirements for the cermet units in the burners of high-pressure sodium-vapor lamps (HPSVL) because the heat resistance is too low. Previously, the following composition was used for HPSVL (mass fraction, %): oxides — 10 – 15 calcium, 1 – 5 zirconium, 5 – 25 niobium, 7 – 15 tungsten, 15 – 17 magnesium, remainder — aluminum oxide; metal — 2 – 3 niobium. Such solders in subsequent HPSVL with improved color rendition for industrial use did not secure the required characteristics; this pertains especially to the burn time. One way to improve the color rendition of HPSVL is to increase the pressure of the sodium and mercury vapors. Such conditions can be created in the burner only by increasing the electric load, i.e., power, overloading the lamp, and correspondingly the cermet solder. This raises the solder temperature considerably; the pressure in the burner increases and the service life of standard HPSVL decreases sharply because of the appearance of longitudinal microcracks in the solder and so on.

To increase the adhesion of solder consisting of polycor and titanium or polycor and niobium, titanium and tungsten must also be introduced into the composition of the CS. Tungsten increases the heat resistance of the CS. Such CS will operate at a higher temperature with improved adhesion to both metal and ceramic. The amount of the addition was determined experimentally [2 – 4].

We have tested standard polycor burners with niobium lead-ins and tungsten activated electrodes, which in terms of geometry and filling corresponded to the burners in DNaT 400 lamps. The burners were sealed by means of the CS composition when using polycor solder and niobium. The burners tested were included in a standard arrangement with a throttle and an integrated ignition setup. The supply voltage (power consumption) was changed by means of a laboratory

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transformer. A VR-20 thermocouple was attached to a solder joint with the appropriated apparatus showing the temperature of the joint. The burner was place inside a vacuum cabinet in order to prevent unsealing in air. A 2NVR-5D pump was used to obtain a vacuum.

The power supplied to the burner was changed in steps from 400 W in increments of 50 W with holding for 30 min. Extinguishment of the burner after 1 h without re-ignition was taken as a criterion of unsealing of the solder joint (the joint temperature was recorded during the operation of the burner). To eliminate random processes, three to five burners were fabricated for each experimental composition of the CS. To obtain a complete picture, in the experiment we also used a standard DNaT 400 burner manufactured by the A. N. Lodygin All-Russia Scientific-Research Institute of Light Sources (VNIIIS) (Saransk, Mordovia).

The following CS compositions were studied (content by weight, wt.%):

prototype: oxides: 10 calcium, 5 zirconium, 20 niobium, 10 tungsten, 15 magnesium, 37 aluminum, to which a metal was added — niobium 3%;

MKP-1: oxides; 40 aluminum, 18 calcium, 12 magnesium, 8 tungsten, 7 niobium, 3 zirconium, to which metals were added: 3 niobium, 5 titanium, 4 tungsten;

MKP-2: oxides: 45 aluminum, 17 calcium, 11 magnesium, 7 tungsten, 7 niobium, 3 zirconium, to which metals were added: 2 niobium, 4.5 titanium, 3.5 tungsten;

MKP-3: oxides: 50 aluminum, 16 calcium, 10 magnesium, 7 tungsten, 6 niobium, 2 zirconium, to which metals were added: 2 niobium, 4 titanium, 3 tungsten.

The loss-of-seal temperatures of the solder joints for the experimental burners are presented in Table 1. A comparative analysis of the test results shows that the composition proposed for the CS makes it possible to increase the working temperature of a solder joint and at the same time preserve the vacuum density of the joint by at least 40°C compared with the prototype. It follows from the table that the compositions proposed for CS, which were developed and used, can increase the working temperature of solder joints by no more than 100°C.

TABLE 1. Unsealing Temperature of Solders

Experimental burner	Joint unsealing temperature, °C				
	DNaT 400	Prototype	MKP-1	MKP-2	MKP-3
1st	864	903	925	970	Current lead-in burned out
2nd			990	995	970
3rd			972	1035	970
4th			–	1008	890
Average temperature, °C	864	903	962	992	943

CONCLUSIONS

The present research led to the development of a solder that made it possible to increase the thermal and adhesion capacity of solder joints. The proposed cermet solder has the following composition (content by weight, %): oxides — 40 – 50 aluminum, 16 – 18 calcium, 10 – 12 magnesium, 7 – 8 tungsten, 6 – 7 niobium, 2 – 3 zirconium; metals — 2 – 3 niobium, 4 – 5 titanium, 3 – 4 tungsten.

This cermet solder can extend the service life of HPSVL with high specific electric load to 12,000 h and considerably improve the quality and significantly expand the practical application of the manufactured lamps.

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